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WATER-QUALITY AND SEDIMENT-CHEMISTRY DATA OF DRAIN WATER AND EVAPORATION PONDS FROM TULARE LAKE DRAINAGE DISTRICT KINGS COUNTY, CALIFORNIA MARCH 1985 TO MARCH 1986

U.S. GEOLOGICAL SURVEY
Open-File Report 87-700

Prepared in cooperation with the
U.S. FISH AND WILDLIFE SERVICE

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By *Roger Fujii*

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6419-20

Sacramento, California
1988

DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

Metric units are used in this report. For readers who prefer inch-pound units, the conversion factors for the terms used in this report are listed below.

Multiply	By	To obtain
cm (centimeter)	0.3937	inch

Water temperature is given in degrees Celsius (°C) which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F = 1.8(°C) + 32.$$

Trace-element and pesticide concentrations in water samples are given in micrograms per liter (µg/L). One thousand micrograms per liter is equivalent to 1 milligram per liter. Micrograms per liter is equivalent to "parts per billion." Trace-element concentrations in bottom sediments are given in micrograms per gram. Micrograms per gram is equivalent to "parts per million."

Pesticide concentrations in bottom sediments are given in micrograms per kilogram (µg/kg). One thousand micrograms per kilogram is equivalent to 1 microgram per gram. Micrograms per kilogram is equivalent to "parts per billion."

Explanation of abbreviations:
µS/cm microsiemens per centimeter at 25°C

WATER-QUALITY AND SEDIMENT-CHEMISTRY DATA OF DRAIN WATER AND EVAPORATION PONDS FROM TULARE LAKE DRAINAGE DISTRICT, KINGS COUNTY, CALIFORNIA, MARCH 1985 TO MARCH 1986

By *Roger Fujii*

ABSTRACT

Trace-element and major-ion concentrations were measured in water samples collected monthly between March 1985 and March 1986 at the MD-1 pumping station at the Tulare Lake Drainage District evaporation ponds, Kings County, California. Samples were analyzed for selected pesticides several times during the year. Salinity, as measured by specific conductance, ranged from 11,500 to 37,600 microsiemens per centimeter; total recoverable boron ranged from 4,000 to 16,000 micrograms per liter; and total recoverable molybdenum ranged from 630 to 2,600 micrograms per liter. Median concentrations of total arsenic and total selenium were 97 and 2 micrograms per liter. Atrazine, prometone, propazine, and simazine were the only pesticides detected in water samples collected at the MD-1 pumping station.

Major ions, trace elements, and selected pesticides also were analyzed in water and bottom-sediment samples from five of the southern evaporation ponds at Tulare Lake Drainage District. Water enters the ponds from the MD-1 pumping station at pond 1 and flows through the system terminating at pond 10. The water samples increased in specific conductance (21,700 to 90,200 microsiemens per centimeter) and concentrations of total arsenic (110 to 420 micrograms per liter), total recoverable boron (12,000 to 80,000 micrograms per liter), and total recoverable molybdenum (1,200 to 5,500 micrograms per liter) going from pond 1 to pond 10, respectively. Pesticides were not detected in water from any of the ponds sampled. Median concentrations of total arsenic and total selenium in the bottom sediments were 4.0 and 0.9 micrograms per gram, respectively. The only pesticides detected in bottom-sediment samples from the evaporation ponds were DDD and DDE, with a maximum concentration of 0.8 microgram per kilogram.

INTRODUCTION

The U.S. Geological Survey in cooperation with the U.S. Fish and Wildlife Service monitored the quality of agricultural drain water at the inlet to the southern evaporation ponds at Tulare Lake Drainage District from March 1985 to March 1986. Water samples were collected once each month at the MD-1 pumping station in Tulare Lake Drainage District evaporation ponds before water entered the southern evaporation ponds (fig. 1). The U.S. Fish and Wildlife Service had tentatively selected this site as the point from which water would be diverted to the proposed experimental marsh development research site at Kern National Wildlife Refuge.

This report describes the results of a study to assess the quality of agricultural drain water for potential use in an experimental pond system and to evaluate the use of this water for marsh development and management on the Kern National Wildlife Refuge. All water samples were analyzed for major ions, nutrients, and trace elements. Selected pesticides were analyzed several times during the sampling period. In addition, water and bottom-sediment samples were collected from southern evaporation ponds 1, 2, 3, 7, and 10 (fig. 1) on November 7, 1985, and analyzed for major constituents, trace elements, and selected pesticides. Water samples from ponds 3 and 10 also were collected in June 1985 and analyzed for trace elements and some major ions.

This report presents and describes data for both the drain water and the evaporation ponds. Also included in the report are previously published data on the quality of agricultural drain water from the San Luis Drain near the inlet to pond 2 at Kesterson Reservoir and bottom-sediment concentrations of trace elements and other inorganic constituents from pond 2 at Kesterson Reservoir (locations shown in figure 2). These data have been included for comparison purposes because a high incidence of deformity and mortality in waterfowl hatchlings has been observed at Kesterson National Wildlife Refuge and has been attributed to high concentrations of selenium in subsurface agricultural drain water from the western San Joaquin Valley, California (Ohlendorf, 1984).

DATA COLLECTION

Water samples were collected using standard field methods (U.S. Geological Survey, 1977). Water samples were analyzed at the U.S. Geological Survey National Water-Quality Laboratory in Denver, Colorado, using U.S. Geological Survey methods (Fishman and Friedman, 1985; Wershaw and others, 1983). Bottom sediments were sampled by using a hand corer whose liner was washed, acid rinsed for inorganic constituents (plastic liner) or acetone rinsed for organic constituents (stainless steel liner), and rinsed several times with pond water prior to sampling. Samples of the top 10 cm of sediment were collected from several locations near the inlet to each pond and composited. Concentrations of pesticides in bottom sediments were determined using U.S. Geological Survey methods (Wershaw and others, 1983) at the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colorado. Inorganic constituents in bottom sediments were analyzed at the Geologic Division Laboratory of the U.S. Geological Survey in Arvada, Colorado (Briggs and Crock, 1986; Crock and others, 1983).

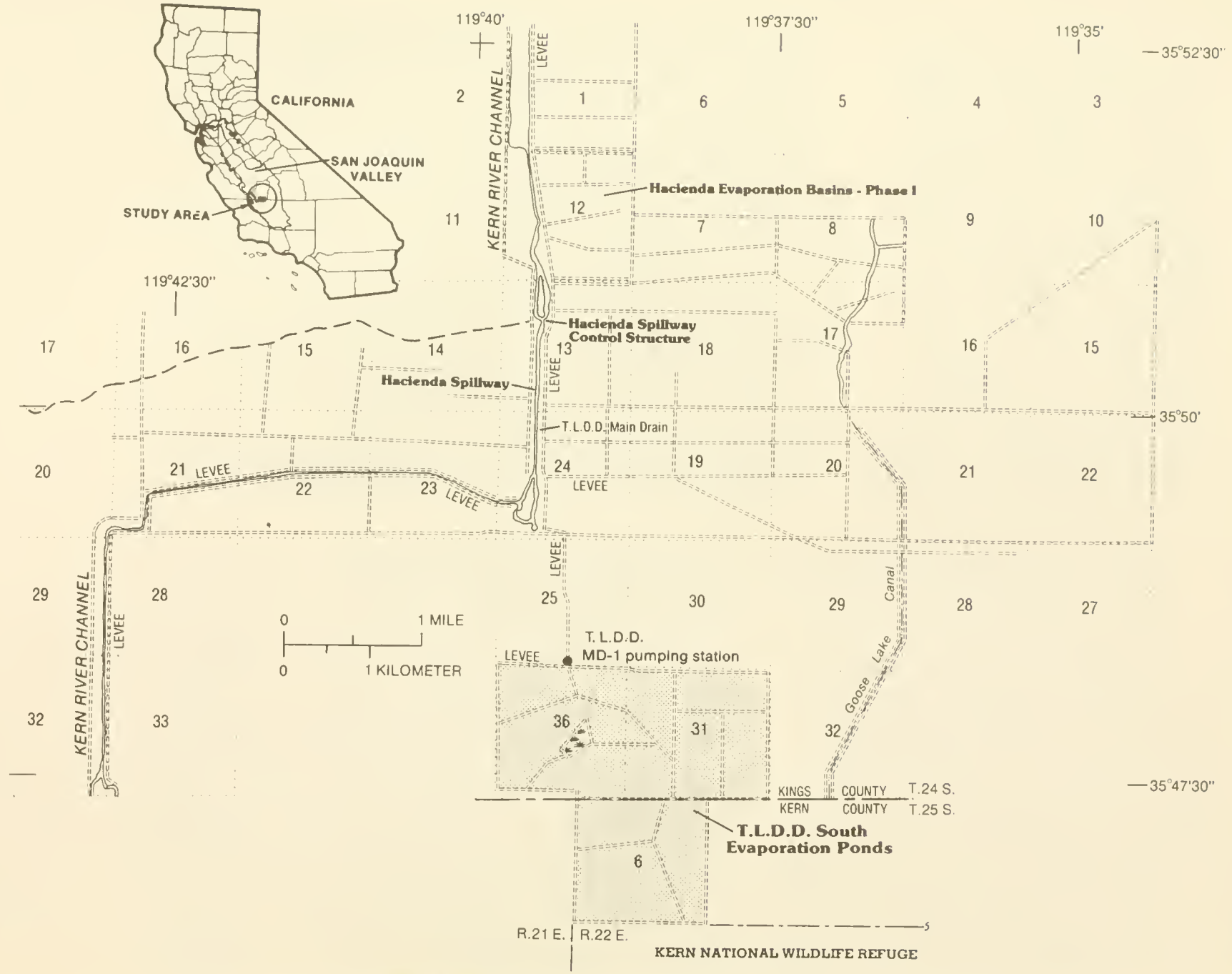

FIGURE 1.- Location of MD-1 pumping station and Tulare Lake Drainage District (T.L.D.D.) southern evaporation ponds.

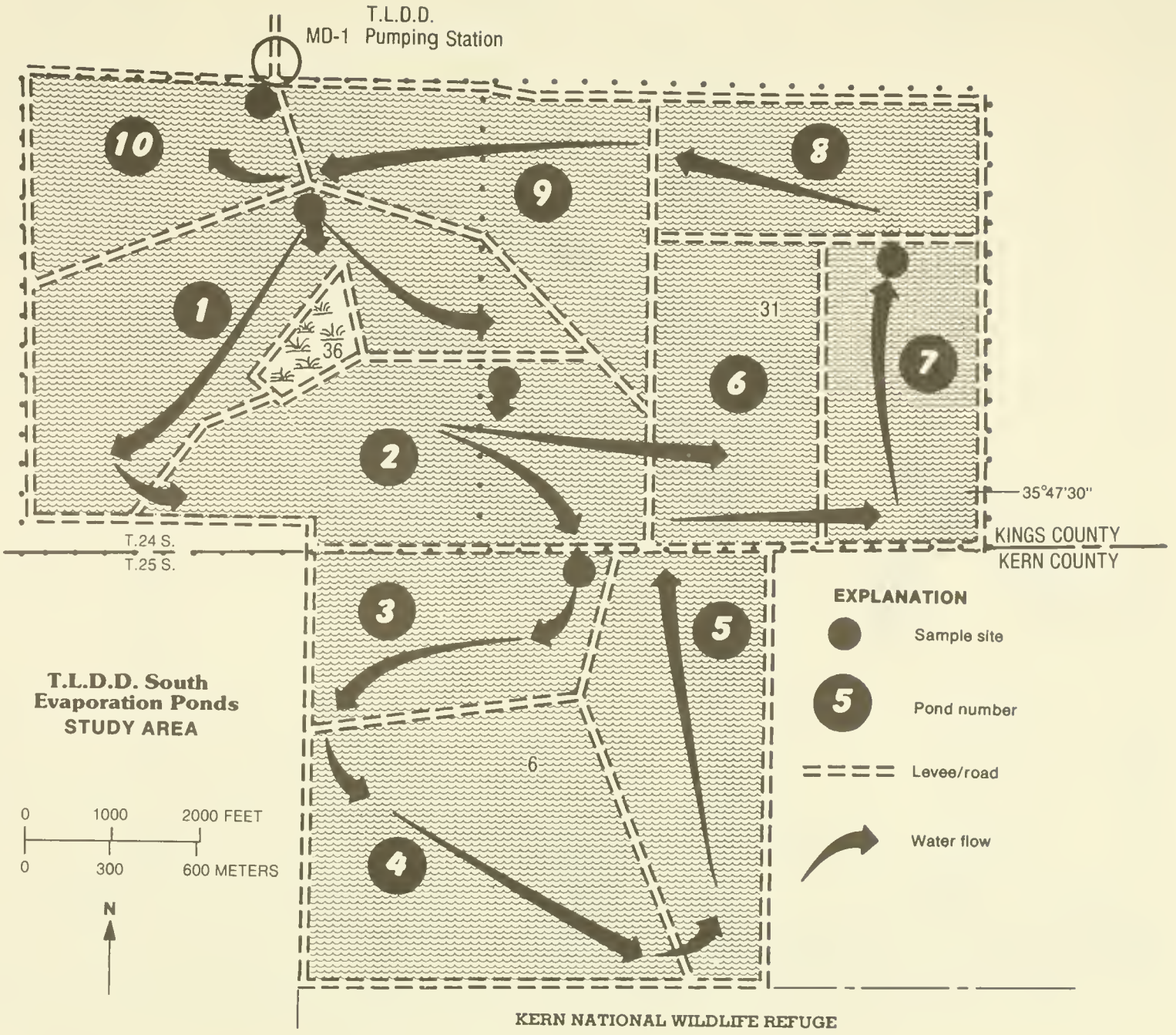

FIGURE 1.- Continued.

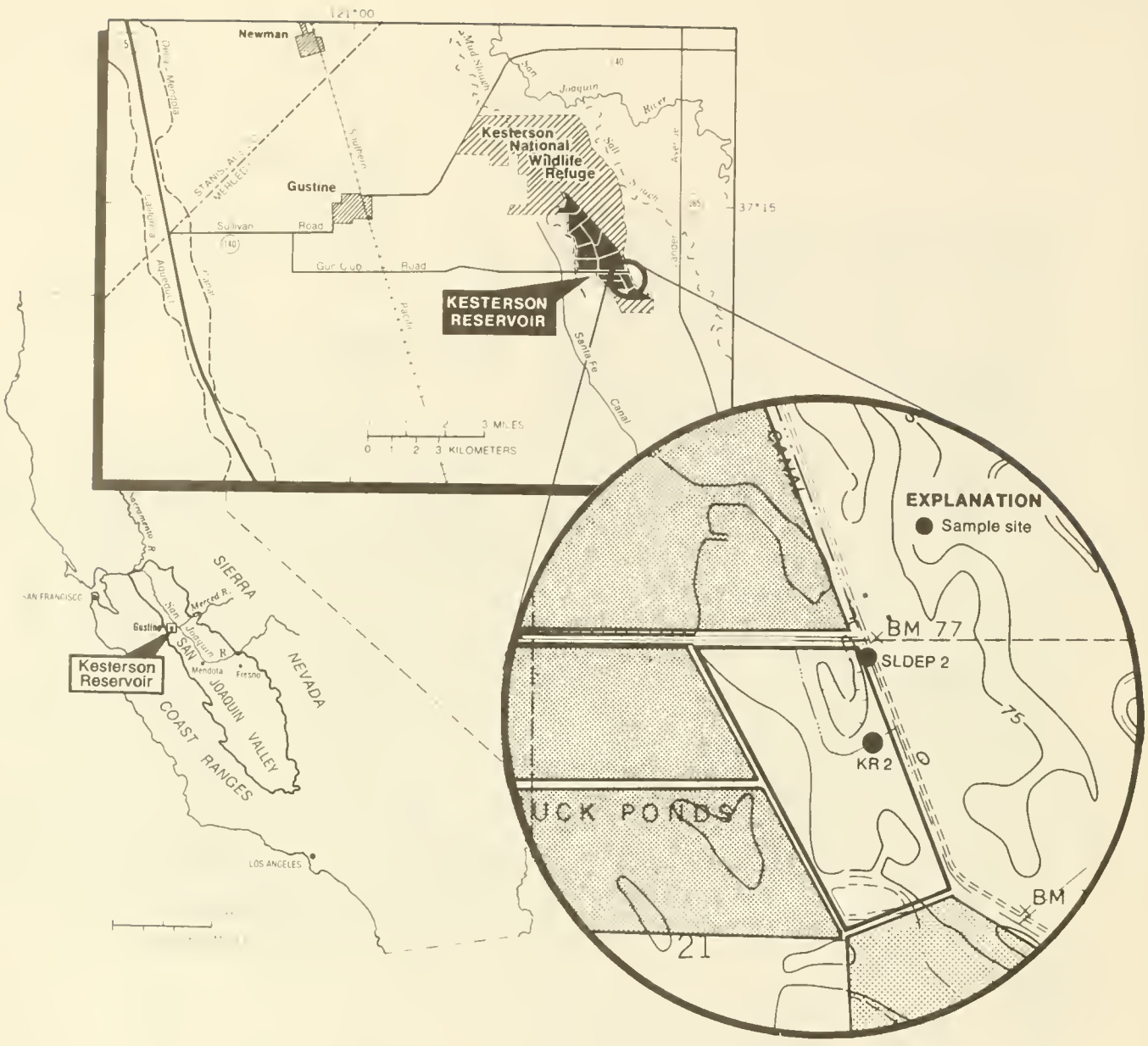

FIGURE 2.- Location of water and sediment sampling locations at Kesterson Reservoir.

RESULTS OF WATER-QUALITY AND SEDIMENT-CHEMISTRY DATA COLLECTION

Monthly Sampling at the MD-1 Pumping Station

Results of the inorganic data collected monthly at the MD-1 pumping station are given in tables 1 through 4 and summarized by range and median values at the bottom of each table. For comparison purposes, table 5 reports range and median values of specific conductance, pH, and selected trace elements of water samples collected by the U.S. Geological Survey from March 1985 to March 1986 at the MD-1 pumping station and water samples collected by the U.S. Bureau of Reclamation from the San Luis Drain near the inlet to pond 2 at Kesterson Reservoir (SLDEP2, fig. 2) from January to December 1985.

Constituents reported in table 5 generally indicate a much larger range of values for water sampled at the MD-1 pumping station compared to SLDEP2. For example, salinity, measured by specific conductance, ranged from 11,500 to 37,600 µS/cm at the MD-1 pumping station and from 9,160 to 12,520 µS/cm at SLDEP2; total recoverable boron ranged from 4,000 to 16,000 µg/L at the MD-1 pumping station and from 13,000 to 17,000 µg/L at SLDEP2; and total recoverable molybdenum ranged from 630 to 2,600 µg/L at the MD-1 pumping station and from 85 to 160 µg/L at the SLDEP2.

Data in table 5 also indicate large differences in concentrations of total arsenic, total recoverable boron, total recoverable molybdenum, and total selenium between water sampled at the MD-1 pumping station and SLDEP2. The median concentration of total selenium at the MD-1 pumping station was 2 µg/L compared to 277 µg/L at SLDEP2. In contrast, the median concentration of total arsenic at the MD-1 pumping station was 97 µg/L compared to less than 1 µg/L at SLDEP2. Therefore, the drain water sampled at the MD-1 pumping station contained lower concentrations of total selenium and higher concentrations of total arsenic than the drain water sampled at SLDEP2. The median boron concentrations were lower and median molybdenum concentrations higher for water sampled at the MD-1 pumping station compared to SLDEP2.

Results of selected pesticide analyses of water samples collected at the MD-1 pumping station at various times during the sampling period are shown in table 6. The only pesticides detected were triazine herbicides. At least one triazine herbicide was detected in each of the samples collected in March, May, and June 1985, with a maximum concentration of 3.0 µg/L for atrazine in June. A list of other pesticides analyzed in water samples and the sampling dates are also given in table 6. Concentrations of these pesticides were less than the detection limits of the methods of analyses in all samples.

Southern Evaporation Ponds

Water and sediment samples were collected at the inlets to ponds 1, 2, 3, and 10 and at the outlet from pond 7 on November 7, 1985. The results presented are for point samples collected in each pond and do not reflect the spatial variability within each pond. Selected field measurements and analyses of carbon, major ions, and nutrients are shown in table 7. Specific conductance ranged from 21,700 to 90,200 µS/cm in ponds 1 and 10. The direction of flow is from pond 1 to pond 10, sequentially, but some water is also diverted from pond 2 to pond 6 directly (fig. 1). The increase in salinity from pond 1 to pond 10, as indicated by the specific conductance of the water, is probably the result of evaporative concentration of dissolved constituents.

TABLE 1.--*Physical properties and field measurements for monthly water samples collected at the MD-1 pumping station*

[Physical properties and field measurements in milligrams per liter, unless otherwise noted; --, not analyzed]

Date of sample	Specific conductance (µS/cm)	pH (standard units)	Temperature (°C)	Oxygen, dissolved	Alkalinity, field (as $CaCO_3$)	Dissolved solids, residue at 180°C	Carbon, organic, total (as C)	Carbon, organic, dissolved (as C)	Carbon, organic, suspended, total (as C)
3-19-85	14,400	8.0	15.0	14.2	697	--	19	--	--
4-23-85	37,600	8.4	27.0	16.8	665	--	42	--	--
5-29-85	15,800	8.3	19.0	14.5	595	--	28	--	--
6-26-85	14,300	8.3	21.0	12.1	580	--	--	39	--
7-19-85	14,900	8.3	22.0	10.6	589	11,400	--	--	1.4
8-16-85	13,700	8.4	23.0	14.3	589	11,100	--	72	1.1
9-13-85	14,300	8.4	19.5	9.8	590	12,500	--	26	2.0
10-25-85	24,900	8.1	15.0	8.8	713	21,500	--	75	2.2
11- 7-85	34,200	8.1	20.0	--	757	--	--	48	0.5
12-18-85	16,900	8.3	9.5	--	687	11,100	29	--	1.0
2- 7-86	11,500	8.1	8.5	12.4	534	9,350	29	--	--
3- 5-86	11,800	8.1	20.0	--	614	8,640	20	--	--
Minimum ...	11,500	8.0	8.5	8.8	534	8,640	19	26	0.5
Median	14,650	8.3	19.75	12.4	604.5	11,100	28.5	48	1.25
Maximum ...	37,600	8.4	27.0	16.8	757	21,500	42	75	2.2

TABLE 2.--*Major-ion analyses for monthly water samples collected at the MD-1 pumping station*

[Major ions in milligrams per liter; --, not analyzed]

Date of sample	Calcium, dissolved	Magnesium, dissolved	Sodium, dissolved	Potassium, dissolved	Bicarbonate (as HCO_3)	Carbonate (as CO_3)	Sulfate, dissolved	Chloride, dissolved	Fluoride, dissolved	Silica, dissolved
3-19-85	190	100	3,500	4	840	--	4,000	2,000	1.4	29
4-23-85	330	570	9,900	20	760	26	15,000	7,900	2.2	12
5-29-85	220	270	3,200	16	710	6	2,800	1,400	1.2	22
6-26-85	--	--	2,900	12	700	--	3,000	1,900	1.5	28
7-19-85	190	250	2,900	13	710	--	5,000	1,400	1.3	22
8-16-85	170	240	2,800	16	690	13	4,800	2,200	1.4	22
9-13-85	280	290	3,300	13	660	10	4,800	2,300	1.7	17
10-25-85	260	350	6,600	16	860	--	8,700	4,400	1.9	27
11- 7-85	230	390	12,000	18	910	--	14,000	810	2.5	16
12-18-85	160	250	3,300	16	820	--	5,200	2,300	1.3	26
2- 7-86	200	230	2,500	11	640	--	4,300	1,700	1.3	26
3- 5-86	70	200	2,100	11	740	--	3,800	1,800	1.4	31
Minimum ...	70	100	2,100	4	640	6	2,800	810	1.2	12
Median	200	250	3,250	14.5	725	11.5	4,800	1,950	1.4	24
Maximum ...	330	570	12,000	20	910	26	15,000	7,900	2.5	31

TABLE 3.--*Analyses of nitrogen and phosphorous for monthly water samples collected at the MD-1 pumping station*

[Nitrogen and phosphorous in milligrams per liter; --, not analyzed]

Date of sample	Nitrogen, nitrate, dissolved (as N)	Nitrogen, nitrite, dissolved (as N)	Nitrogen, nitrate plus nitrite, dissolved (as N)	Nitrogen, ammonia plus organic, total (as N)	Nitrogen, ammonia, dissolved (as N)	Phosphorus, total (as P)	Phosphorus, dissolved (as P)	Phosphorus, ortho, dissolved (as P)
3-19-85	26	0.11	26	--	--	--	--	0.66
4-23-85	--	<.01	<.10	--	--	--	--	.02
5-29-85	17	.18	17	--	--	--	--	.55
6-26-85	--	--	23	2.2	0.14	0.84	0.79	.81
7-19-85	--	--	14	4.9	.10	.84	.35	.28
8-16-85	--	--	17	3.1	.07	.87	.56	.41
9-13-85	--	--	18	3.7	.18	.80	.43	.39
10-25-85	--	--	8.7	2.9	.12	.73	.60	.57
11- 7-85	--	--	<.10	8.3	.19	.27	.20	.19
12-18-85	32	.19	32	2.7	.20	1.2	1.0	1.2
2- 7-86	12	.14	12	2.3	.16	1.0	1.0	.98
3- 5-86	20	.12	20	1.9	.05	.95	.94	.95
Minimum	12	<0.01	<0.10	1.9	0.05	0.27	0.20	0.02
Median	20	.13	17	2.9	.14	.84	.60	.56
Maximum	32	.19	32	8.3	.20	1.2	1.0	1.2

TABLE 4.--*Trace-element analyses for monthly water samples collected at the MD-1 pumping station*

[Trace elements in micrograms per liter; --, not analyzed]

Date of sample	Aluminum, total recoverable	Aluminum, dissolved	Antimony, total	Arsenic, total	Arsenic, dissolved	Barium, total recoverable	Barium, dissolved	Beryllium, total recoverable	Beryllium, dissolved	Boron, total recoverable
3-19-85	700	30	<1	190	78	300	--	<10	--	--
4-23-85	300	20	1	64	66	200	--	20	--	--
5-29-85	400	<10	5	98	90	300	--	10	--	--
6-26-85	800	20	--	120	85	<100	<100	<10	<10	6,200
7-19-85	900	10	--	94	66	100	<100	<10	<10	4,000
8-16-85	900	30	--	120	11	<100	<100	10	<10	6,700
9-13-85	2,300	10	--	92	81	100	100	10	10	8,600
10-25-85	300	10	--	96	96	<100	80	10	--	16,000
11- 7-85	70	10	--	64	62	<100	<100	10	10	--
12-18-85	500	<10	--	110	110	<100	<100	<10	<10	5,500
2- 7-86	1,500	<10	--	74	71	<100	100	<10	<10	4,600
3- 5-86	1,100	10	--	100	99	100	100	<10	<10	4,900
Minimum ...	70	<10	<1	64	11	<100	80	<10	<10	4,000
Median	750	10	1	97	79.5	<100	<100	<10	<10	5,850
Maximum ...	2,300	30	5	190	110	300	100	20	10	16,000

Date of sample	Boron, dissolved	Cadmium, total recoverable	Cadmium, dissolved	Chromium, total recoverable	Chromium, dissolved	Cobalt, total recoverable	Copper, total recoverable	Copper, dissolved	Iron, total recoverable	Iron, dissolved
3-19-85	6,100	1	2	20	<1	2	10	8	790	60
4-23-85	28,000	3	1	40	<1	2	7	3	460	110
5-29-85	7,200	1	2	10	<1	2	10	5	420	50
6-26-85	5,700	<1	--	3	<1	--	9	6	690	40
7-19-85	4,000	<1	2	<1	<1	--	8	5	930	80
8-16-85	460	1	1	3	<1	--	6	8	870	80
9-13-85	8,300	2	1	9	<1	--	20	7	3,100	60
10-25-85	1,700	1	--	7	<1	--	6	4	260	--
11- 7-85	29,000	<1	<1	5	<1	--	4	2	250	120
12-18-85	6,200	<1	<1	10	1	--	9	6	590	50
2- 7-86	4,700	<1	<1	20	<1	--	6	3	1,600	50
3- 5-86	5,100	<1	3	10	<1	--	9	8	1,100	40
Minimum ...	460	<1	<1	<1	<1	2	4	2	250	40
Median	5,900	<1	1	9.5	<1	2	8.5	5.5	740	60
Maximum ...	29,000	3	3	40	1	2	20	8	3,100	120

TABLE 4.--*Trace-element analyses for monthly water samples collected at the MD-1 pumping station--Continued*

Date of sample	Lead, total recoverable	Lead, dissolved	Lithium, total recoverable	Lithium, dissolved	Manganese, total recoverable	Manganese, dissolved	Mercury, total recoverable	Mercury, dissolved	Molybdenum, total recoverable	Molybdenum, dissolved
3-19-85	<1	<1	120	120	210	150	--	<0.1	630	1,000
4-23-85	2	3	340	330	680	550	--	<.1	2,600	2,500
5-29-85	8	4	150	140	250	210	--	<.1	1,100	1,100
6-26-85	2	2	130	150	120	80	0.6	<.1	1,900	1,300
7-19-85	<1	3	130	130	260	160	<.1	.2	1,500	1,500
8-16-85	3	1	120	100	140	80	<.1	<.1	1,200	--
9-13-85	<1	<1	160	100	390	150	.1	<.1	--	--
10-25-85	2	<1	230	--	400	370	<.1	.2	--	1,500
11- 7-85	1	<1	340	370	630	620	<.1	<.1	1,100	--
12-18-85	<1	<1	90	90	220	190	.1	.3	760	760
2- 7-86	<1	2	90	90	410	320	<.1	.1	700	700
3- 5-86	2	<2	100	100	200	80	<.1	<.1	700	600
Minimum ...	<1	<1	90	90	120	80	<0.1	<0.1	630	600
Median	1.5	<1	130	120	255	175	<.1	<.1	1,100	1,100
Maximum ...	8	4	340	370	680	620	.6	.3	2,600	2,500

Date	Nickel, total recoverable	Nickel, dissolved	Selenium, total	Selenium, dissolved	Silver, total recoverable	Silver, dissolved	Strontium, total recoverable	Vanadium, dissolved	Zinc, total recoverable	Zinc, dissolved
3-19-85	20	8	34	37	<1	<1	1,300	100	20	20
4-23-85	10	8	<1	<1	<1	<1	3,400	310	30	30
5-29-85	7	9	29	5	<1	<1	1,300	120	10	20
6-26-85	20	16	2	6	<1	--	--	--	50	20
7-19-85	20	8	1	<1	<1	<1	--	--	30	40
8-16-85	10	9	<1	1	1	1	--	--	20	40
9-13-85	30	7	<1	2	1	<1	--	--	40	20
10-25-85	8	8	2	2	1	<1	--	--	60	--
11- 7-85	10	6	<1	<1	<1	<1	--	--	40	40
12-18-85	10	5	26	25	<1	1	--	--	20	20
2- 7-86	20	7	10	10	1	<1	--	--	30	20
3- 5-86	20	11	20	20	<1	<1	--	--	20	20
Minimum	7	5	<1	<1	<1	<1	1,300	100	10	20
Median	15	8	2	3.5	<1	<1	1,300	120	30	20
Maximum	30	16	34	37	1	1	3,400	310	60	40

TABLE 5.--*Summary of selected constituents in water sampled at the MD-1 pumping station from March 1985 to March 1986 and at the San Luis Drain near the inlet to pond 2 at Kesterson Reservoir (SLDEP2) from January to December 1985 (John Fields, U.S. Bureau of Reclamation, written commun., 1986)*

	MD-1 pumping station	San Luis Drain near evaporation pond 2
Field measurements		
Specific conductance (µS/cm)		
Minimum	11,500	9,160
Median	14,650	11,825
Maximum	37,600	12,520
pH (standard units)		
Minimum	8.0	7.9
Median	8.3	8.5
Maximum	8.4	8.9
Trace elements (µg/L)		
Arsenic, total		
Minimum	64	<1
Median	97	<1
Maximum	190	2
Boron, total recoverable		
Minimum	4,000	13,000
Median	5,850	14,500
Maximum	16,000	17,000
Molybdenum, total recoverable		
Minimum	630	85
Median	1,100	100
Maximum	2,600	160
Selenium, total		
Minimum	<1	186
Median	2	277
Maximum	34	430

TABLE 6.--*Pesticide analyses for water samples collected at the MD-1 pumping station, 1985*

[--, not analyzed]

Compounds (µg/L)	March 19	May 29	June 26	August 16	September 13
Triazine herbicides, total					
Ametryne	<0.1	<0.1	<0.1	--	--
Atrazine	2.7	--	3.0	--	--
Cyanazine	<.1	<.1	<.1	--	--
Prometone	.2	.1	.2	--	--
Prometryne	<.1	--	<.1	--	--
Propazine	.1	--	.1	--	--
Simetryne	<.1	<.1	<.1	--	--
Simazine	.1	--	.1	--	--
Organochlorine compounds, total					
Aldrin	--	--	--	<0.01	<0.01
Chlordane	--	--	--	<.1	<.1
DDD	--	--	--	<.01	<.01
DDE	--	--	--	<.01	<.01
DDT	--	--	--	<.01	<.01
Dieldrin	--	--	--	<.01	<.01
Endosulfan	--	--	--	<.01	<.01
Endrin	--	--	--	<.01	<.01
Heptachlor	--	--	--	<.01	<.01
Heptachlor epoxide	--	--	--	<.01	<.01
Lindane	--	--	--	<.01	<.01
Methoxychlor	--	--	--	<.01	<.01
Mirex	--	--	--	<.01	<.01
Napthalenes	--	--	--	<.01	<.01
PCB	--	--	--	<.01	<.01
Perthane	--	--	--	<.01	<.01
Toxaphene	--	--	--	<1	<1
Organophosphorous Insecticides					
Ethion					
total	--	--	--	<0.01	<0.01
dissolved	<0.01	<0.01	--	--	--
Diazinon					
total	--	--	--	<.01	<.01
dissolved	<.01	--	--	--	--
Malathion					
total	--	--	--	<.01	<.01
dissolved	<.01	--	--	--	--
Methyl parathion					
total	--	--	--	<.01	<.01
dissolved	<.01	<.01	--	--	--
Methyl trithion					
total	--	--	--	<.01	<.01
dissolved	<.01	<.01	--	--	--
Parathion					
total	--	--	--	<.01	<.01
dissolved	<.01	<.01	--	--	--
Trithion					
total	--	--	--	<.01	<.01
dissolved	<.01	<.01	--	--	--

TABLE 7.--*Analyses of selected constituents for water samples collected at Tulare Lake Drainage District ponds 1, 2, 3, 7, and 10; November 7, 1985*

[Constituents are in milligrams per liter; --, not analyzed]

Constituent or property	Pond 1	Pond 2	Pond 3	Pond 7	Pond 10
Specific conductance (µS/cm)	21,700	23,800	34,200	32,400	90,200
pH (standard units)	9.4	8.9	8.8	8.8	8.6
Temperature (°C)	23.5	16.0	16.0	16.0	14.5
Carbon, organic, dissolved (as C)	52	75	120	--	320
Carbon, organic, suspended total (as C)	0.4	2.6	5.2	--	3.6
Calcium, total recoverable	90	70	80	70	--
Calcium, dissolved	--	--	--	--	110
Magnesium, total recoverable	340	480	770	730	--
Magnesium, dissolved	--	--	--	--	2,200
Sodium, total recoverable	4,800	5,700	9,300	7,600	--
Sodium, dissolved	--	--	--	--	36,000
Potassium, total recoverable	18	26	40	34	--
Potassium, dissolved	--	--	--	--	120
Alkalinity, field (as $CaCO_3$)	374	410	567	495	997
Sulfate, dissolved	--	--	--	--	52,000
Chloride, dissolved	--	--	--	--	28,000
Fluoride, dissolved	--	--	--	--	2.6
Silica, dissolved	--	--	--	--	7.5
Nitrogen, nitrite, total (as N)	0.04	0.06	0.05	0.03	--
Nitrogen, NO_2+NO_3, total (as N)	<0.10	<0.10	<0.10	<0.10	--
Nitrogen, NO_2+NO_3, dissolved (as N)	--	--	--	--	<0.10
Nitrogen, ammonia + organic, total (as N)	--	--	--	--	20
Phosphorus, total (as P)	0.56	0.52	0.34	0.32	0.24

Trace-element analyses of water sampled from ponds 1, 2, 3, 7, and 10 on November 7, 1985 are shown in table 8. Many of the trace-element concentrations also were larger in pond 10 than pond 1. For example, concentrations of total arsenic increased from 110 µg/L in pond 1 to 420 µg/L in pond 10; total recoverable boron increased from 12,000 µg/L in pond 1 to 80,000 µg/L in pond 10; and total recoverable molybdenum increased from 1,200 µg/L in pond 1 to 5,500 µg/L

TABLE 8.--*Trace-element analysis for water samples collected at Tulare Lake Drainage District ponds 1, 2, 3, 7, and 10; November 7, 1985*

[Trace elements are in micrograms per liter; --, not analyzed]

Trace element	Pond 1	Pond 2	Pond 3	Pond 7	Pond 10
Aluminum, total recoverable	--	--	--	--	150
Aluminum, dissolved	--	--	--	--	20
Arsenic, total	110	140	170	150	420
Arsenic, dissolved	--	--	--	--	400
Barium, total recoverable	--	--	--	--	100
Barium, dissolved	--	--	--	--	<100
Beryllium, total recoverable	--	--	--	--	20
Beryllium, dissolved	--	--	--	--	30
Boron, total recoverable	12,000	13,000	20,000	18,000	80,000
Boron, dissolved	--	--	--	--	76,000
Cadmium, total recoverable	--	--	--	--	<1
Cadmium, dissolved	--	--	--	--	<1
Chromium, total recoverable	7	5	4	6	2
Chromium, dissolved	--	--	--	--	<1
Copper, total recoverable	2	2	2	1	3
Copper, dissolved	--	--	--	--	3
Iron, total recoverable	180	260	260	160	560
Iron, dissolved	--	--	--	--	370
Lead, total recoverable	1	1	3	2	3
Lead, dissolved	--	--	--	--	2
Lithium, total recoverable	170	210	310	270	770
Lithium, dissolved	--	--	--	--	720
Manganese, total recoverable	50	40	50	40	120
Manganese, dissolved	--	--	--	--	100
Mercury, total recoverable	<0.1	<0.1	<0.1	<0.1	<0.1
Mercury, dissolved	--	--	--	--	<0.1
Molybdenum, total recoverable	1,200	1,600	2,200	1,700	5,500
Nickel, total recoverable	--	--	--	--	15
Nickel, dissolved	--	--	--	--	9
Selenium, total	21	29	27	23	25
Selenium, dissolved	16	25	20	17	7
Silver, total recoverable	--	--	--	--	<1
Silver, dissolved	--	--	--	--	<1
Zinc, total recoverable	20	20	30	20	70
Zinc, dissolved	--	--	--	--	80

in pond 10. Dissolved selenium concentrations did not follow the pattern of increasing from pond 1 to pond 10.

Water from ponds 3 and 10 also was sampled on June 26, 1985, and analyzed for selected dissolved constituents and specific conductance. The results of the analyses are shown in table 9. Dissolved constituents and specific conductance increase from pond 3 to pond 10.

Analyses of inorganic constituents and carbon in bottom sediments taken from ponds 1, 2, 3, 7, and 10 on November 7, 1985 are shown in table 10. Results of these analyses excluding carbon species are summarized in table 11 by range and median concentrations of elements. Also included in table 11 are sediment data from Kesterson Reservoir, pond 2 (KR2; fig. 2) sampled once in May 1985.

Comparison between the sediment data from the Tulare Lake Drainage District ponds and KR2 indicates considerable differences in some major and trace constituent concentrations. Calcium was greater in the sediments from the Drainage District ponds (median, 67,000 µg/g) than from KR2 (17,000 µg/g); but the iron concentration of the sediments from KR2 (23,000 µg/g) was greater than that from the Drainage District ponds (median, 8,200 µg/g). Concentrations of chromium and nickel were about four times higher in sediments from KR2 than the Drainage District pond sediments, and concentrations of several other trace elements such as cobalt, copper, vanadium, and zinc were about twice as high in the KR2 sediments than in the Drainage District pond sediments. The selenium concentration of the KR2 sediments is shown in table 11 as 5.2 µg/g, which is larger than the median concentration of 0.9 µg/g of selenium for the Drainage District pond sediments. Selenium concentrations larger than 100 µg/g have been detected in sediments at Kesterson Reservoir (John Fields, U.S. Bureau of Reclamation, written commun., 1986). The median arsenic concentration of the Drainage District pond sediments was 4.0 µg/g. The arsenic value shown in table 11 for KR2 sediments is less than the detection limit of 10 µg/g. Bottom-sediment concentrations of arsenic at Kesterson Reservoir ponds ranged from 1.2 to 4.5 µg/g with a median concentration of 1.75 µg/g in December 1984 and the sample from pond 2 contained 1.8 µg/g of arsenic (John Fields, U.S. Bureau of Reclamation, written commun., 1986). Thus, comparison of selenium and arsenic concentrations at the Tulare Lake Drainage District ponds and KR2 indicate that similar to water, selenium concentrations in sediment were larger at KR2 than at the Drainage District ponds, but arsenic concentrations were generally larger at the Drainage District ponds than at KR2.

Water and bottom sediments sampled from ponds 1, 2, 3, 7, and 10 on November 7, 1985 were analyzed for the pesticides shown in table 12. The only compounds

TABLE 9.--*Analyses of dissolved constituents and specific conductance for water samples collected at Tulare Lake Drainage District ponds 3 and 10; June 26, 1985*

[Constituents are in micrograms per liter; specific conductance is in microseimens per centimeter. --, not analyzed]

Constituent or property	Pond 3	Pond 10
Specific conductance	29,400	110,000
Arsenic	110	260
Barium	--	--
Beryllium	<10	20
Cadmium	2	--
Chromium	<1	<1
Copper	<2	--
Iron	80	320
Lead	4	--
Lithium	300	--
Manganese	30	80
Mercury	<0.1	<0.1
Molybdenum	5,000	13,000
Nickel	<2	--
Potassium	27	160
Selenium	1	2
Silver	<2	--
Zinc	30	80

TABLE 10.--*Analyses of total inorganic constituents and carbon in bottom sediments collected at Tulare Lake Drainage District ponds 1, 2, 3, 7, and 10; November 7, 1985*

[Inorganic constituents and carbon are in micrograms per gram]

Constituent	Pond 1	Pond 2	Pond 3	Pond 7	Pond 10
Aluminum	63,000	62,000	62,000	57,000	54,000
Calcium	67,000	70,000	45,000	80,000	36,000
Iron	12,000	10,000	8,200	7,900	8,100
Magnesium	10,000	9,300	9,800	13,000	7,400
Sodium	27,000	26,000	34,000	26,000	29,000
Phosphorus	700	600	500	500	400
Potassium	23,000	23,000	24,000	24,000	23,000
Titanium	2,000	1,700	1,400	1,200	1,300
Arsenic	4.7	4.0	6.1	2.9	3.0
Barium	660	730	740	690	690
Beryllium	--	1	1	1	1
Bismuth	<10	<10	<10	<10	<10
Cadmium	<2	<2	<2	<2	<2
Cerium	39	41	30	36	28
Chromium	14	13	12	11	10
Cobalt	5	5	4	4	4
Copper	7	6	4	7	5
Europium	<2	<2	<2	<2	<2
Gallium	13	12	12	11	11
Gold	<8	<8	<8	<8	<8
Holmium	<4	<4	<4	<4	<4
Lanthanum	20	22	17	20	16
Lead	10	10	10	20	10
Lithium	20	20	20	20	20
Manganese	490	390	220	230	230
Molybdenum	22	18	20	3.0	<2
Neodymium	17	16	14	15	12
Nickel	10	8	7	7	7
Scandium	3	3	3	<2	2
Selenium	2.3	0.9	1.6	0.3	0.2
Silver	<2	<2	<2	<2	<2
Strontium	1,000	760	620	830	450
Tantalum	<40	<40	<40	<40	<40
Thorium	7	6	4	9	5
Tin	<20	<20	<20	<20	<20
Uranium	<100	<100	<100	<100	<100
Vanadium	40	30	28	21	21
Yttrium	11	11	10	13	9
Ytterbium	1	1.0	1.0	1	1
Zinc	30	20	20	20	20
Carbon, total (as C)	23,600	18,600	17,400	23,300	10,600
Carbon, organic (as C)	6,300	2,400	7,600	800	1,300
Carbon, carbonate (as C)	17,300	16,200	9,800	22,500	9,300

TABLE 11.--*Summary of total bottom-sediment concentrations of trace elements and other constituents from Tulare Lake Drainage District, ponds 1, 2, 3, 7, and 10 sampled on November 7, 1985, and bottom-sediment concentrations of trace elements and other constituents from Kesterson Reservoir, pond 2 sampled in May 1985 (John Fields, U.S. Bureau of Reclamation, written commun., 1986)*

[Constituents are in micrograms per gram]

Constituent	Tulare Lake Drainage District, southern evporation ponds 1, 2, 3, 7, and 10			Kesterson Reservoir pond 2
	Minimum	Median	Maximum	
Aluminum	54,000	62,000	63,000	74,000
Calcium	36,000	67,000	80,000	17,000
Iron	7,900	8,200	12,000	23,000
Magnesium	7,400	9,800	13,000	6,700
Sodium	26,000	27,000	34,000	23,000
Phosphorous	400	500	700	300
Potassium	23,000	23,000	24,000	26,000
Titanium	1,200	1,400	2,000	2,200
Arsenic	2.9	4.0	6.1	<10
Barium	660	690	740	820
Beryllium	1	1	1	1
Bismuth	<10	<10	<10	<10
Cadmium	<2	<2	<2	<2
Cerium	28	36	41	44
Cobalt	4	4	5	8
Chromium	10	12	14	45
Copper	4	6	7	9
Europium	<2	<2	<2	<2
Gallium	11	12	13	14
Gold	<8	<8	<8	<8
Holmium	<4	<4	<4	<4
Lanthanium	16	20	22	20
Lead	10	10	20	20
Lithium	20	20	20	20
Manganese	220	230	490	350
Molybdenum	<2	18	22	<2
Neodymium	12	15	17	22
Nickel	7	7	10	32
Scandium	<2	3	3	6
Selenium	0.2	0.9	2.3	5.2
Silver	<2	<2	<2	<2
Strontium	450	760	1,000	330
Tantalum	<40	<40	<40	<40
Thorium	4	6	9	12
Tin	<20	<20	<20	<20
Uranium	<100	<100	<100	<100
Vanadium	21	28	40	55
Yttrium	9	11	13	15
Ytterbium	1.0	1.0	1.0	2.0
Zinc	20	20	30	39

detected were DDD and DDE in bottom sediments. Bottom sediments from ponds 1, 2, 3, 7, and 10 contained DDE concentrations of 0.7, 0.8, 0.8, 0.6, and 0.8 µg/kg. DDD was detected in bottom sediments from pond 2 only, 0.2 µg/kg. The remaining pesticide analyses were less than the detection limits shown in table 12.

TABLE 12.--*Detection limits of pesticides analyzed in water and bottom-sediment samples collected at Tulare Lake Drainage District, ponds 1, 2, 3, 7, and 10; November 7, 1985*

[--, not analyzed]

Compounds	Detection limit	
	Water (µg/L)	Bottom sediments (µg/kg)
Organochlorine compounds, total		
Aldrin	0.01	0.1
Chlordane	.1	1.0
*DDD	.01	.1
*DDE	.01	.1
DDT	.01	.1
Dieldrin	.01	.1
Endosulfan	.01	.1
Endrin	.01	.1
Heptachlor	.01	.1
Heptachlor epoxide	.01	.1
Lindane	.01	.1
Methoxychlor	.01	.1
Mirex	.01	.1
Naphthalenes	.1	1.0
PCB	.1	1.0
Perthane	.1	1.0
Toxaphene	1.0	10
Organophosphorous compounds, total		
Diazinon	.01	--
Ethion	.01	--
Malathion	.01	--
Methyl parathion	.01	--
Methyl trithion	.01	--
Parathion	.01	--
Trithion	.01	--

*Only pesticides detected in bottom sediments.

SUMMARY

Trace-element and major-ion concentrations were measured in water samples collected monthly between March 1985 and March 1986 at the MD-1 pumping station at the Tulare Lake Drainage District evaporation ponds, Kings County, California. Samples were analyzed for selected pesticides several times during the year. Salinity, as measured by specific conductance, ranged from 11,500 to 37,600 µS/cm; total recoverable boron ranged from 4,000 to 16,000 µg/L; and total recoverable molybdenum ranged from 630 to 2,600 µg/L. Median concentrations of total arsenic and total selenium were 97 and 2 µg/L. Atrazine, prometone, propazine, and simazine were the only pesticides detected in water samples collected at the MD-1 pumping station.

Major ions, trace elements, and selected pesticides also were analyzed in water and bottom-sediment samples from five of the southern evaporation ponds at Tulare Lake Drainage District. Water enters the ponds from the MD-1 pumping station at pond 1 and flows through the system terminating at pond 10. The water samples increased in specific conductance (21,700 to 90,200 µS/cm) and concentrations of total arsenic (110 to 420 µg/L), total recoverable boron (12,000 to 80,000 µg/L), and total recoverable molybdenum (1,200 to 5,500 µg/L) going from pond 1 to pond 10, respectively. Pesticides were not detected in water from any of the ponds sampled. Median concentrations of total arsenic and total selenium in the bottom sediments were 4.0 and 0.9 µg/g, respectively. The only pesticides detected in bottom-sediment samples from the evaporation ponds were DDD and DDE, with a maximum concentration of 0.8 µg/kg.

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